HEWLETT-PACKARD COMPANY
Intellectual Property Administration
P. O. Box 272400
Fort Collins, Colorado 80527-2400

PATENT APPLICATION

ATTORNEY DOCKET NO. 10006298-1

IN THE
UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Amir Said

Confirmation No.: 5635

Application No.: 09/912,278

Examiner: Colin M. Larose

Filing Date: 7/24/2001

Group Art Unit: 2623

Title: IMAGE BLOCK CLASSIFICATION BASED ON ENTROPY OF DIFFERENCES

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TRANSMITTAL OF APPEAL BRIEF

Sir:

Transmitted herewith is the Appeal Brief in this application with respect to the Notice of Appeal filed on April 18,2005.

The fee for filing this Appeal Brief is (37 CFR 1.17(c)) $500.00.

(complete (a) or (b) as applicable)

The proceedings herein are for a patent application and the provisions of 37 CFR 1.136(a) apply.

( ) (a) Applicant petitions for an extension of time under 37 CFR 1.136 (fees: 37 CFR 1.17(a)-(d) for the total number of months checked below:

( ) one month $120.00
( ) two months $450.00
( ) three months $1020.00
( ) four months $1590.00

( ) The extension fee has already been filled in this application.

(X) (b) Applicant believes that no extension of time is required. However, this conditional petition is being made to provide for the possibility that applicant has inadvertently overlooked the need for a petition and fee for extension of time.

Please charge to Deposit Account **08-2025** the sum of $500.00. At any time during the pendency of this application, please charge any fees required or credit any over payment to Deposit Account 08-2025 pursuant to 37 CFR 1.25. Additionally please charge any fees to Deposit Account 08-2025 under 37 CFR 1.16 through 1.21 inclusive, and any other sections in Title 37 of the Code of Federal Regulations that may regulate fees. A duplicate copy of this sheet is enclosed.

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Number of pages: 18

Typed Name: Hugh P. Gortler

Signature: [signature]

Rev 12/04 (Aplbrief)

Respectfully submitted,

Amir Said

By [signature]

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Attorney/Agent for Applicant(s)

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Patent
Docket No. 10006298-1

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BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

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APPEAL NO. ________________

In re Application of:
Amir Said

Serial No. 09/912,278
Filed: July 24, 2001

Confirmation No. 5635
Examiner: Colin M. Larose
Art Unit: 2623

For: **IMAGE BLOCK CLASSIFICATION BASED ON ENTROPY OF DIFFERENCES**

APPEAL BRIEF

I hereby certify that this correspondence is being facsimile transmitted to the United States Patent and Trademark Office on April 19, 2005.

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Reg. No. 33,890

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INDEX

1. REAL PARTY IN INTEREST

The real party in interest is the assignee, Hewlett-Packard Company.

2. RELATED APPEALS AND INTERFERENCES

No appeals or interferences are known to have a bearing on the Board's decision in the pending appeal.

3. STATUS OF CLAIMS

Claims 2-10, 12-18, and 20-30 are pending.

Claims 9-10, 17-18 and 23-24 are objected to.

Claims 2-8, 12-16, 20-22 and 25-30 are rejected.

The rejections of claims 2-8, 12-16, 20-22 and 25-30 are being appealed.

4. STATUS OF AMENDMENTS

An amendment was filed subsequent to final rejection. The amendment was entered.

5. SUMMARY OF CLAIMED SUBJECT MATTER

Independent claims 2, 19, 23 and 28

The present invention relates to detecting whether blocks of pixels in digital images contain edges (application paragraph 1). Examples of an edge include a boundary between two objects in a scene, and a boundary between an object and a background. Edges occurring in computer-generated images (e.g., text documents, CAD drawings, line art) are usually more abrupt than edges occurring in natural images (e.g., photos).

Knowledge of whether pixel blocks contain edges can be useful. For example, the knowledge can used to improve compression of digital images (application paragraph 29, last line).

Claim 2 recites a method of detecting an edge in a digital image block. The method comprises creating a histogram of pixel luminance differences in the block (Figure 1, block 110; paragraph 17). Exemplary histograms are illustrated in Figures 2a-2d and described in paragraphs 18-19. The histograms of Figures 2a-2d indicate the number of occurrences (frequencies) at which pixel differences occur in a block. An example of computing a histogram for a 4x4 block is provided in paragraph 20, lines 1—10, and the corresponding histogram is illustrated in Figure 3.

The method of claim 2 further comprises computing entropy of the histogram (Figure 1, block 112; paragraph 19). An example of computing the entropy of the histogram of Figure 3 is provided in paragraph 20, lines 10—12.

Claim 28 recites a method of detecting an edge in a digital image block. The method comprises determining an entropy of a histogram of the block.

Claim 12 recites apparatus for detecting edges in an image block. The apparatus includes a processor for creating a histogram of pixel luminance differences in the block, and computing entropy of the histogram. An exemplary apparatus including a processor (314) is illustrated in Figure 5 and described in application paragraph 29.

Claim 25 recites an article for a processor. The article comprises memory and a program stored in the memory. When executed, the program causes the processor to determine whether an image block contains an edge. The determination includes creating a histogram of the pixel luminance differences in the block, and computing the entropy of the histogram. An exemplary article (312) is illustrated in Figure 5 and described in application paragraph 29.

<u>Dependent claims 5, 14 and 20</u>

Pixel noise presents a problem with detecting edges in pixel blocks. An edge can be characterized by a large change in intensity between adjacent pixels. However, noise can be characterized similarly.

Claim 5 recites the method of claim 1, further comprising determining a maximum pixel difference in the block (Figure 1, block 116, application paragraph 20). Claim 14 recites the apparatus of claim 12, wherein the processor (314) determines a maximum pixel difference in the block. Claim 20 recites the article (312) of claim 25, wherein the program also causes the processor to determine a maximum pixel difference in the block and use the maximum difference to determine whether the block contains at least one edge.

As discussed in paragraph 20 of the application, smooth regions are characterized by low entropy and a low maximum difference, regions having large random differences (e.g., noise) are characterized by high entropy and a high maximum difference, and regions having edges are characterized by low entropy and a high maximum difference.

6. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 2, 12, 25, and 28-30 are rejected under 35 USC §103 as being unpatentable over Manduca et al. U.S. Patent No. 6,329,819 in view of Dhawan et al. U.S. Patent No. 5,271,064. Claims 5, and 20 are rejected under 35 USC §103 as being unpatentable over Manduca et al. in view of Rafferty U.S. Patent No. 5,377,018. Claim 14 is rejected under 35 USC §103 as being unpatentable over Manduca et al. in view of Dhawan et al. and Rafferty.

7. ARGUMENTS

REJECTION OF CLAIMS 2-4, 12-13 AND 25-30 UNDER 35 U.S.C §103 OVER MANDUCA ET AL AND DHAWAN ET AL.

Manduca et al. do not appear to disclose edge detection. Manduca et al. appear to disclose an autocorrection method for reducing motion artifacts in magnetic resonance (MR) images (col. 1, lines 10-12). Artifacts such as blurring and ghosting can result from patient motion (col. 1, lines 35-37 and col. 4, lines 14-15). Manduca et al.'s method includes performing motion correction by defining a measure or metric of image quality, evaluating different possible combinations of motion, and searching for a set that optimizes the metric (col. 4, lines 30-35). Entropy is used as the metric (col. 5, line 43 to col. 6, line 20). The metric is based on calculating the entropy of normalized variance of the gradient of the MR image (col. 3, lines 10-15).

The advisory action states that column 5, lines 50-60 of Manduca et al.

> expressly teaches that the entropy of pixel differences (i.e., the gradient) detects the relative quality of edges present in a given block. In addition, Manduca teaches that for areas of uniform brightness the gradient is zero everywhere except at edges, so according to equation (1), the entropy of the gradient is zero for an image block that does not contain an edge.

First, the statement is not on point. Independent claims 2, 12, 25 and 28 recite taking entropy of frequencies of differences (histograms), not the entropy of pixel differences (gradients).

Second, the statement is not accurate. Here is what column 5, lines 43-60 of Manduca et al. expressly teaches.

> The success of the autocorrection method depends upon the appropriate choice of an image quality metric. A good metric for autocorrection must not only show appropriate a improvement as blurring and ghosting are reduced but, more importantly, must correlate well with an expert observer's opinion of image quality. We have developed new metrics based on the gradient of the image. One of these is the entropy of the gradient of the image. This quantity is minimized when the image consists of areas of uniform brightness, separated by sharp edges, since in such a case, the gradient is zero everywhere except at the edges, where it has high values. This is a fairly good model for what is expected in MR images of the body in ideal situations. Any blurring or ghosting will increase the entropy of the gradient, since the gradient will be non-zero at more points and will take on smaller values at the actual edge location. One phase-encoding preferred cost function, or metric (F_1) applies a one-dimensional gradient operator along the direction and then calculates the entropy of this gradient.

Thus, the passage at column 5, lines 43-60 describes a measure of image quality. An image is adjusted until the entropy (the metric) indicates that the "best" image has been obtained. The passage does not teach or suggest generating

histograms of pixel differences. The passage does not teach or suggest computing entropies of histograms. Manduca et al.'s approach does not even provide information that indicates whether a block contains an edge.

Dhawan et al. disclose a method of enhancing elements in a digital image. The method includes classifying elements as either a surface or edge element (col. 3, lines 59-63), and adjusting the elements to increase the differences between elements at edges from the elements in shadows (col. 3, lines 63-67). Dhawan et al. do not teach or suggest using entropy to detect the edges. Dhawan et al. use entropy of a contrast vector histogram to determine whether contrast enhancement in the image has been maximized (col., 9, lines 36-38). Edges are detected by searching for zero crossings of contrast vectors (col. 10, lines 44-56).

Because neither Dhawan et al. nor Manduca et al. teach or suggest edge detection in a pixel block by computing the entropy of a histogram of the pixel block, the '103 rejections of claims 2-4, 12-13 and 25-30 should be withdrawn. Accordingly, claims 2-4, 12-13 and 25-30 should be allowed. Claims 5-8, 14-16 and 20-22 should also be allowed, since they depend from claims 2, 12 and 25.

REJECTION OF CLAIMS 5-8 AND 20-22 UNDER 35 U.S.C §103 OVER MANDUCA ET AL. AND RAFFERTY

Manduca et al. are silent about improving edge detection in the presence of noise (since they are silent about edge detection in general).

Rafferty discloses an edge detection technique for a pixel block. As illustrated in Figures 7A-7C, the technique includes determining the difference between the minimum and maximum luminance values (blocks 52-68), and comparing the difference to a threshold (block 70). Rafferty does not teach or suggest how this technique can be used to distinguish noise from edges. Rafferty does not teach or suggest combining this technique with entropy of a histogram of pixel luminance differences.

Thus, the combined teachings of Manduca et al. and Rafferty do not produce the method of claim 5 or the article of claim 20. For this additional reason, claims 5 and 20 and their dependent claims 6-8 and 21-22 should be allowed.

REJECTION OF CLAIMS 14-16 UNDER 35 U.S.C §103 OVER MANDUCA ET AL., RAFFERTY AND DHAWAN ET AL.

As indicated in the previous arguments, both Manduca et al. and Rafferty are silent about improving edge detection in the presence of noise. Unlike Manduca et al, Rafferty discloses an edge detection technique. However, Rafferty does not teach or suggest combining his simple thresholding approach with the entropy of a histogram.

Dhawan et al. are also silent about improving edge detection in the presence of noise. Although Dhawan et al. address noise, they address it in the context of correcting edge sharpness (col. 4, lines 39-51). Further, they do not teach or suggest edge detection that combines entropy of a histogram of a pixel block with maximum pixel difference in the block.

Thus, the combined teachings of Manduca et al., Rafferty and Dhawan et al. do not produce the method of claim 5 or the article of claim 20. For this additional reason, claim 14 and its dependent claims 15-16 should be allowed.

For the reasons above, the rejections of claims 2-8, 12-16, 20-22 and 25-30 should be withdrawn. The Honorable Board of Patent Appeals and Interferences is respectfully requested to reverse the rejections of these claims

Respectfully submitted,

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Date: April 19, 2005

8. CLAIMS APPENDIX

1. (Cancelled)

2. (Previously presented) A method of detecting an edge in a digital image block, the method comprising creating a histogram of pixel luminance differences in the block; and computing entropy of the histogram.

3. (Original) The method of claim 2, wherein entropies for bins of the histogram are pre-computed and stored in a lookup table; and wherein the lookup table is used to determine the entropy of the histogram.

4. (Original) The method of claim 3, wherein entries of the lookup table are scaled and rounded to integers.

5. (Previously presented) The method of claim 2, further comprising determining a maximum pixel difference in the block.

6. (Original) The method of claim 5, further comprising comparing the entropy and maximum difference to thresholds to determine whether the block contains an edge.

7. (Original) The method of claim 5, wherein a block containing edges is identified by a low entropy and a high maximum difference.

8. (Original) The method of claim 5, wherein the block is identified as not having an edge if the maximum difference is zero.

9. (Previously presented) A method of detecting an edge in a digital image block, the method comprising determining an entropy according to the function

$$E(h) = \log(T) - \frac{1}{T}\sum_{h_n \neq 0} h_n \log(h_n).$$

10. (Original) The method of claim 9, wherein the entropy function is normalized.

11. (Cancelled)

12. (Previously presented) Apparatus for detecting edges in an image block, wherein the apparatus includes a processor for creating a histogram of pixel luminance differences in the block; and computing entropy of the histogram.

13. (Original) The apparatus of claim 12, wherein the processor includes a look-up table of pre-computed bin entropies a function of bin height; and wherein the processor looks up entropies for bins of the histogram and sums the bin entropies to determine the entropy of the histogram.

14. (Original) The apparatus of claim 12, wherein the processor also determines a maximum pixel difference in the block.

15. (Original) The apparatus of claim 14, wherein the processor compares the entropy and maximum difference to thresholds to determine whether the block contains an edge.

16. (Original) The apparatus of claim 15, wherein the processor identifies a block having low entropy and a high maximum difference as a block containing at least one edge.

17. (Previously presented) Apparatus for detecting edges in an image block by determining entropies in the block according to the function

$$E(h) = \log(T) - \frac{1}{T}\sum_{h_n \neq 0} h_n \log(h_n).$$

18. (Original) The apparatus of claim 17, wherein the processor uses a normalized version of the entropy function to detect whether the block contains at least one edge.

19. (Cancelled)

20. (Previously presented) The article of claim 25, wherein the program also causes the processor to determine a maximum pixel difference in the block and use the maximum difference to determine whether the block contains at least one edge.

21. (Previously presented) The article of claim 20, wherein a block containing edges is identified by a low entropy and a high maximum difference.

22. (Previously presented) The article of claim 20, wherein the block is identified as not having an edge if the maximum difference is zero.

23. (Previously presented) An article for a processor, the article comprising:

memory; and

a program stored in the memory, the program, when executed, causing the processor to determine whether an image block contains an edge by determining an entropy according to the function

$$E(h) = \log(T) - \frac{1}{T}\sum_{h_n \neq 0} h_n \log(h_n).$$

24. (Previously presented) The article of claim 23, wherein the entropy function is normalized.

25. (Previously presented) An article for a processor, the article comprising:

memory; and

a program stored in the memory, the program, when executed, causing the processor to determine whether an image block contains an edge, the determination including creating a histogram of the pixel luminance differences in the block; and computing the entropy of the histogram.

26. (Previously presented) The article of claim 25, wherein entropies for bins of the histogram are pre-computed and stored in a lookup table; and wherein the lookup table is used to determine the entropy of the histogram.

27. (Previously presented) The article of claim 26, wherein entries of the lookup table are scaled and rounded to integers.

28. (Previously presented) A method of detecting an edge in a digital image block, the method comprising determining an entropy of a histogram of the block.

29. (Previously presented) Apparatus comprising a processor for performing the method of claim 28.

30. (Previously presented) An article comprising memory encoded with data for causing a processor to perform the method of claim 28.